Description

METHOD FOR PARTITIONING RESOURCE SPACE, ASSIGNING PHYSICAL CHANNEL, AND ALLOCATING POWER IN OFDMA-BASED CELLULAR SYSTEM

Technical Field

[1]   The present invention relates to an OFDMA(Orthogonal Frequency Division Multiple Access)-based cellular system. Morespecifically, the present invention relates to a method for partitioningresource spaces, assigning physical channels, and allocating power in anOFDMA-based cellular system for configuring a physical link resource with aplurality of resource spaces, and configuring a resource space with a pluralityof resource subspaces to easily control inter-cell interference for eachchannel characteristic in an OFDMA-based cellular system.

Background Art

[2]   In general, ISI (Inter-Symbol Interference)according to multiple paths is generated to receive signals when transmittingsignals through a multi-path channel. In particular, the ISI is furtherreinforced in the case of high-speed data transmission since a symbol period isless than a delay spread of a channel, and hence, more complex receivingmethods are required so as to compensate for distortion caused by the ISI andrestore accurate transmit signals. In order to reduce a distortion phenomenonof signals caused by the ISI, the symbol period is to be greater than the delayspread of the channel, and the OFDM method has been proposed as a modulationmethod for simply compensating for the distortion of the multi-pathchannel.

[3]   The OFDM method uses a plurality of subcarriershaving orthogonality to transmit data, differing from the transmission methodwhich uses single carriers. That is, the OFDM method performs serial andparallel conversion on the input data by the number of subcarriers used formodulation, and modulates the respective converted data by using thecorresponding subcarriers to thereby maintain data rates and increase thesymbol period for each subcarrier by the number of subcarriers. Since the OFDMmethod uses subcarriers having orthogonality, it has better bandwidthefficiencies and longer symbol periods compared to the existing FDM (FrequencyDivision Multiplex) method, and it has an ISI-resistance characteristiccompared to the single carrier modulation method.

[4]   The modulation and demodulation process at atransmitter and a receiver in the OFDM system corresponds to execution of IDFT(Inverse Discrete Fourier Transform)

and DFT (Discrete Fourier Transform), andit can also be realized effectively by using IFFT (Inverse Fast FourierTransform) and FFT (Fast Fourier Transform). Further, when a guard intervalwhich is longer than the delay spread of the channel is inserted for eachsymbol period, the inter-carrier orthogonality is maintained to generate no ICI(Inter-Carrier Interference), and no OFDM symbols caused by the multi-pathchannel are superimposed to completely eliminate adjacent inter-symbol ISI.

[5]   The conventional TDMA-based cellular system uses adifferent frequency in the adjacent cell to reduce interference by other cells.The method, however, reduces the total system capacity because of low frequencyreuse efficiencies. The existing CDMA-based cellular system, such as the IS-95,the CDMA2000, and the W-CDMA, uses spread spectrum codes to decreaseinterference caused by channels of other cells by the spread components, andaverages the interference of various channels of the cells to use the identicalfrequency in the adjacent cell. However, the IEEE802.11a, the Hiperlan/2, andthe DAB (Digital Audio Broadcasting) on the conventional OFDM basis have beendesigned in environments other than that for the cellular system, and nocon-sideration for reducing the inter-cell interference has been studied. Inthis instance, the inter-cell interference is reduced by using a differentfrequency in the adjacent cell, but the frequency reuse efficiencies aredegraded, and the system capacity is decreased.

[6]   In order to improve the frequency reuse efficienciesin the above-noted OFDMA-based cellular system, the dynamic packet allocationmethod and the dynamic channel allocation method are used (refer to 'Network-assisted resource management for wireless data networks, ' by X. Qiu,K. Chawla, J. C. I. Chuang, and N. Sollenberger, IEEE Selected Areas Commun.,Vol.19, pp. 1222-1234, July 2001). Adjacent cells communicate with signaling,and they do not transmit data to the channel which another adjacent cell uses.This method gives good theoretical performance, but it is not appropriate forthe actual systems because of a large amount of overheads.

[7]   Further, the OFDMA-based cellular system uses thefrequency hopping method to average the inter-cell interference, and usesdifferent frequency hopping patterns for the respective cells so that a channelof a cell may uniformly collide with many channels of another cell, and theinter-cell interference may accordingly be averaged, which is disclosed by theOFDMA method of the IEEE802.16a. However, since the IEEE802.16a averages theinterference without distinguishing the channels, the required SNR (Signal toNoise Ratio) is also averaged since the channels are mixed, and hence, it isdifficult to control the inter-cell interference.

Disclosure of Invention
Technical Problem

[8]   *Technical Problem*

[9]   It is an advantage of the present invention to provide a method for partitioning resource spaces and assigning channels and power for easily controlling inter-cell interference for respective channels having different characteristics, and enhancing frequency reuse efficiencies in an OFDMA-based cellular system.

Technical Solution

[10]   In one aspect of the present invention, a method for partitioning resource spaces and assigning physical channels and power in an OFDMA-based cellular system, comprises:

[11]   (a) partitioning a resource within a slot into resource spaces, in common in a plurality of adjacent cells;

[12]   (b) partitioning the partitioned resource spaces into resource sets according to respective sizes of physical channels in the adjacent cells; and

[13]   (c) assigning the physical channels classified based on characteristics to the partitioned resource sets within the resource space.

[14]   In another aspect of the present invention, a method for partitioning resource spaces and assigning physical channels and power in an OFDMA-based cellular system, comprises:

[15]   (a) partitioning a resource within a slot into resource spaces, in common in a plurality of adjacent cells;

[16]   (b) partitioning the partitioned resource spaces into resource subspaces, in common in the adjacent cells;

[17]   (c) partitioning the partitioned resource spaces and the resource subspaces into resource sets according to respective sizes of physical channels in the adjacent cells; and

[18]   (d) assigning the physical channels classified based on characteristics to the partitioned resource sets within the resource space and the resource subspace.

[19]   The resource space is partitioned so that a combination of the total or part of common channels, dedicated control channels, shared control channels, dedicated traffic channels, and shared traffic channels is allocated in a resource space.

[20]   The step (b) comprises partitioning the resource space through which the common channel, the dedicated control channel, and the shared control channel of each cell into

resource subspaces so that the channels with similar physical channel characteristics may be transmitted at a subspace.

[21]   The resource set is partitioned to be collided as uniformly as possible with all the resource sets within the same resource space of another adjacent cell.

[22]   The resource set is partitioned to be collided as uniformly as possible with all the resource sets within one of the same resource space and the resource subspace of another adjacent cell.

[23]   The subcarriers which constitute the resource space are configured by a subcarrier set which covers wide frequency band and has a predetermined spacing between constituent adjacent sub-carriers.

[24]   The subcarrier which configures the resource space and the resource subspace is configured by a subcarrier set which covers at least one wide frequency band and has a predetermined interval.

[25]   The method comprises: allocating a transmit power of the resource space to a physical channel which uses a fixed transmit power from among the physical channels assigned to the resource set; and allocating a power within the maximum transmit power of the resource space to a physical channel which uses a variable transmit power from among the physical channels assigned to the resource set.

[26]   The method further comprises: allocating a transmit power of the resource subspace to a physical channel which uses a fixed transmit power from among the physical channels assigned to the resource set; and allocating a power within the maximum transmit power of the resource subspace to a physical channel which uses a variable transmit power from among the physical channels assigned to the resource set.

[27]   The transmit power is allocated by considering cell sizes, interference of adjacent cells, and a required SNR.

[28]   The maximum transmit power is allocated by considering cell sizes, interference of adjacent cells, and a required SNR.

[29]   The method further comprises: partitioning the resource space through which the traffic channel is transmitted into resource subspaces by the number of adjacent cells according to a cell arrangement; and allowing a transmit power higher than that of another resource subspace to a resource subspace for each cell, and differentiating the resource subspace with the allowed high transmit power for each adjacent cell.

[30]   A user who needs a high transmit power for each cell is allowed to use a traffic channel of the resource subspace with the allowed high transmit power.

Advantageous   Effects

[31]

Brief Description of the Drawings

[32] *Description of Drawings*

[33] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, serve to explain the principles of the invention:

[34] FIG. 1 shows a frame configuration of an OFDMA-based cellular system according to a preferred embodiment of the present invention;

[35] FIG. 2 shows an exemplified schematic diagram for partitioning a resource space, a resource subspace, and a resource set according to a preferred embodiment of the present invention;

[36] FIG. 3 shows an exemplified schematic diagram for assigning physical channels to respective resource sets in an OFDMA-based cellular system according to a preferred embodiment of the present invention;

[37] FIG. 4 shows an exemplified partition of traffic resource sets when a resource space through which a traffic channel will be transmitted is not partitioned into resource subspaces in an OFDMA-based cellular system according to a preferred embodiment of the present invention;

[38] FIG. 5 shows a case for partitioning a resource space through which a traffic channel will be transmitted into a plurality of resource subspaces, and allowing different maximum transmit powers of the respective resource subspaces to increase frequency reuse efficiencies in an OFDMA-based cellular system according to a preferred embodiment of the present invention; and

[39] FIG. 6 shows a flowchart for partitioning resource spaces, resource subspaces, and resource sets, and assigning physical channels and transmit powers in an OFDMA-based cellular system according to a preferred embodiment of the present invention.

Best Mode

[40] In the following detailed description, only the preferred embodiment of the invention has been shown and described, simply by way of illustration of the best mode contemplated by the inventor(s) of carrying out the invention. As will be realized, the invention is capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive.

[41] With reference to drawings, operations of partitioning resource spaces and assigning physical channels and power in an OFDMA-based cellular system according

to a preferred embodiment of the presentinvention will be described.

[42]   FIG. 1 shows a frame configuration of anOFDMA-based cellular system according to a preferred embodiment of the presentinvention.

[43]   In an FDD (Frequency Division Duplex) system,physical link signals of an uplink and a downlink include slots 100a and 100bwhich continue with respect to time and are distinguishable by differentfrequency bands.

[44]   In a TDD (Time Division Duplex) system, thephysical link signals use the same frequency band, and an uplink slot 100d anda downlink slot 100c are divided with respect to time.

[45]   Each slot 100a, 100b, 100c, and 100d includesresources 110 of as many as the product of a number of subcarriers used fortransmission and a number of OFDM symbols within a slot. A length of a slot anda number of resources within a slot can be fixed or variable.

[46]   FIG. 2 shows an exemplified schematic diagram forpartitioning a resource space, a resource subspace, and a resource setaccording to a preferred embodiment of the present invention.

[47]   Referring to FIG. 2, the slot of the OFDMA-basedcellular system is partitioned into resource spaces A (200), resource spaces B(201), and resource spaces C (202), and the resource spaces C are partitionedinto first resource subspaces 210 and second resource subspaces 211.

[48]   Also, the resource space A is partitioned intothree resource sets 221, the resource space B is partitioned into two resourcesets 222, the first resource subspace is partitioned into six resource sets223, and the second resource subspace is partitioned into six resource sets224.

[49]   In this instance, adjacent cells Cell1 and Cell2have the same resource spaces 200, 201, and 202 and resource subspaces 210 and211, but the resource sets 221, 222, 223, and 224 are different, and a singleresource set of a resource space of a single cell is arranged to be collided asuniformly as possible with the resource sets of the same resource space ofanother cell.

[50]   The arrangement is varied according to the numberof the resource sets and the number of resources of a single resource set. Forexample, the arrangement can be performed according to pseudorandom codes, andin particular, the resource sets of a cell can be uniformly arranged andsuperimposed on the resource sets of an adjacent cell by as many as the numberobtained by dividing the number of resources of the resource sets by the numberof resource sets, when a number of resource sets, a number

of adjacent cells,and a number of resources of a single resource set are appropriately selected.One exemplar thereof is disclosed in ' Channel coding strategies for cellularradio ' by G.J. Pottie and R. Calderbank, IEEE Trans. Vehic. Techn, Vol. 44,pp. 763-770, November 1995.

[51]   Differing from the above-described conventionalpatent and transaction, the preferred embodiment of the present invention ischaracterized in that the resource sets of an adjacent cell are collided asuniform as possible within a single resource space or a resource subspace, andthe resource sets of different resource spaces or resource subspaces are notcollided with each other.

[52]   Here, the methods of configuring the resourcespaces or resource subspaces are not restricted by specific methods. That is,the different resource spaces can be distinguished by time or frequency withina slot, and in general, the configuration is performed by combining the timeand frequency distinguishments.

[53]   Also, frequency diversity is obtained byconfiguring subcarriers which constitute a single resource space or a resourcesubspace to a single subcarrier set or a plurality of subcarrier sets having apredetermined spacing and covering a wide frequency bandwidth, and reducespower consumption using a partial Fourier transform in the case of a mobilestation for receiving physical channels provided in the corresponding resourcespace or resource subspace (refer to ' Multi-carrier digital communications:theory and application of OFDM ' by A.R.S. Bahai and B.R. Salzberg, KluwerAcademic, NJ, USA, pp.25-27 for the partial Fourier transform.)

[54]   FIG. 3 shows an exemplified schematic diagram forassigning physical channels to respective resource sets in an OFDMA-basedcellular system according to a preferred embodiment of the presentinvention.

[55]   The cellular system generally includes acommonchannel 300 which is commonly used for the cells, a dedicated control channel310 allocated to the users, a dedicated traffic channel 320 allocated to theusers, a shared control channel 330 shared by part of the users, and a sharedtraffic channel 340 shared by part of the users, and for example, the dedicatedcontrol channel 310 from among the respective channel categories can further bedivided into channels 311 and 312 which have different characteristics, such asreceive powers, according to functions, sizes, modulation methods, and encodingmethods of the dedicated control channel 310. In this instance, the commonchannel 300, the dedicated control channel 310, and the shared control channel330 which have the same required receive power are transmitted in a bundlethrough resource sets of a single resource space or a resource subspace. Thatis, the channels of

an adjacent cell which influences the common channel or thecontrol channel of a cell are established to be channels which havecharacteristics, such as the required receive power, similar to the above-notedchannels.

[56]   When the required receive power is different, thetransmit power becomes different, and when a channel with a greater transmitpower and a channel with a lesser transmit power are mixed, the channel with alesser transmit power is substantially interfered. However, since the channelswith similar transmit powers are interfered in the preferred embodiment, theinterference of the adjacent cell is easily controlled.

[57]   Also, differing from the common channels and thecontrol channels, the traffic channels 340 use various modulation methods andencoding methods according to channel conditions and traffic amounts, andaccordingly, the resource space 350 through which the traffic channels 340 aretransmitted is partitioned into at least one resource subspace 360, and thetraffic channels are transmitted through the resource sets 370 of therespective resource subspaces 360.

[58]   FIG. 3 shows a case of using two resourcesubspaces, and when a single resource subspace 360, through which the trafficchannel 340 is transmitted, is provided, the single traffic channel 340 isinterfered by all the traffic channels in the adjacent cell as uniformly aspossible, and when plural resource subspaces 360 are provided, the trafficchannel 340 is interfered by the traffic channel within the same resourcesubspace of the adjacent cell.

[59]   Therefore, the effect of averaging the inter-cellinterference is the largest when a single resource subspace is provided, butthe transmit power of the resource subspace through which the traffic channelis transmitted for each cell is effectively controlled to thereby easilycontrol the inter-cell interference, and the frequency reuse efficiencies ofthe cellular system can be increased by considering the control of the transmitpower at the time of configuring sectors and arranging the cells.

[60]   FIG. 4 shows an exemplified partition of trafficresource sets when a resource space through which a traffic channel will betransmitted is not partitioned into resource subspaces in an OFDMA-basedcellular system according to a preferred embodiment of the presentinvention.

[61]   Referring to FIG. 4, the resource space throughwhich the traffic channels will be transmitted is not partitioned into resourcesubspaces in the OFDMA-based cellular system, but the traffic channel of a cellis controlled to be collided as uniformly as possible with all the trafficchannels of another cell to thus average the inter-cell interference.

[62]   That is, the traffic resource space 400 ispartitioned into a plurality of resource sets

410, and they are allocated tothe traffic channels 420. In this instance, the resource sets

410 arepartitioned for each cell so that the traffic channels of a cell may becollided as

uniformly as possible with all the traffic channels of anothercell.

[63]   FIG. 4 exemplifies a case of partitioning resourcesets in the two cells so that the

0th resource set 430 of the Cell 0may be uniformly collided with the six resource sets

of the Cell 4. This methodis more appropriate for the case in which the radius of the

cell is large whenthe traffic density is not high.

[64]   FIG. 5 shows a case for partitioning a resourcespace through which a traffic

channel will be transmitted into a plurality ofresource subspaces, and which allows

different maximum transmit powers of therespective resource subspaces to increase

frequency reuse efficiencies in anOFDMA-based cellular system according to a

preferred embodiment of the presentinvention. That is, FIG. 5 shows a method for

using a resource subspace throughwhich a plurality of traffic channels will be

transmitted, and which allows atransmit power in a single resource subspace higher

than a transmit power inanother resource subspace for each cell, thereby increasing the

frequency reuseefficiencies of the cellular system.

[65]   In detail, a traffic channel of a normal resourcesubspace is assigned to a user 580 (a

user who stays within the cell), to whomit is able to transmit traffic channels with less

power within a cell, and atraffic channel of the resource subspace allowed with a high

transmit power isassigned to a user 590 (a user who stays on the border of a cell), to

whom itis required to transmit them with high power. As a result, the user within

thecell is rarely interfered by the adjacent cell because of attenuation, and theuser on

the border the cell is rarely interfered by the adjacent cell since theadjacent cell does

not increase the power transmitted to the same resourcesubspace in the adjacent cell.

[66]   In FIG. 5, a high power is allocated to the firstresource subspace 530 in Cell 0, and

a normal power is allocated to the secondand third resource subspaces 540 and 550

when three traffic resource subspacesare respectively used by the two cells Cell0 and

Cell 4.

[67]   In a like manner, a high power is allocated to thesecond resource subspace 510 in

Cell 4, and a normal power is allocated to thefirst and third resource subspaces 500 and

520. Accordingly, in Cell 0, thetraffic channels are transmitted to the user 580 who

stays in the cell size 560which is used for transmission with a normal power through

the second or thirdresource subspace (the first resource subspace can also be used), and

thetraffic channels are transmitted only through the first resource subspace tothe user

590 who stays inside the cell size 570 which is used for transmissionwith a high power and stays outside the cell size 560 which is used fortransmission with a normal power. In this instance, the user 580 who stays inthe cell size 560 at the transmission with a normal power is less interfered byCell 4 since the user 580 is far from Cell 4, and the user 590 who stays insidethe cell size 570 at the transmission with a high power and stays outside thecell size 560 at the transmission with a normal power is less interfered sinceCell 4 transmits a normal power to the corresponding resource subspace (thefirst resource subspace) even though the user 590 is not far from Cell 4.

[68]   Therefore, as given in FIG. 5, a system having afrequency reuse efficiency of 1 can be configured while maintaining theinter-cell interference similar to that of a system having a frequency reuseefficiency of 1/3. This method generates more effects by applying the number oftraffic subspaces in consideration of cell arrangement and sectorarrangement.

[69]   FIG. 6 shows a flowchart for partitioning resourcespaces, resource subspaces, and resource sets, and assigning physical channelsand transmit powers in an OFDMA-based cellular system according to a preferredembodiment of the present invention.

[70]   Referring to FIGs. 3 and 6, a resource within aslot is partitioned into resource spaces 350 in common from a plurality ofadjacent cells so that a combination of part or all of the common channels 300,the dedicated control channels 310, the shared control channels 320, thededicated traffic channels 330, and the shared traffic channels 340 isallocated in a resource space in step S610.

[71]   The partitioned resource spaces 350 are partitionedagain into resource subspaces 360 in common in a plurality of adjacent cells ifnecessary in step S620. In this instance, the resource spaces through which thecommon channel, the dedicated control channel, and the shared control channelare transmitted can be partitioned into resource subspaces so that the channelshaving the similar physical channel characteristics may be transmitted in asingle subspace.

[72]   The partitioned resource spaces 350 and theresource subspaces 360 are partitioned into resource sets 370 according tosizes of the respective physical channels in the adjacent cells so that aresource set 370 within the resource space 350 or the resource subspace 360 maybe collided as uniformly as possible with all the resource sets within the sameresource space or resource subspace of another adjacent cell in step S630.

[73]   The physical channels having the similarcharacteristics are respectively assigned to the partitioned resource sets 370within the resource space 350 or the resource subspace 360 in step S640.

[74]   A transmit power of the resource space 350 or theresource subspace 360 is
assigned to the physical channel which uses a fixedtransmit power from among the
assigned physical channels in consideration ofcell sizes, interference of adjacent cells,
and required SNR in step S650.

[75]   A transmit within the maximum transmit power of theresource space 350 or the
resource subspace 360 is assigned to the physicalchannel which uses a variable
transmit power from among the assigned physicalchannels in consideration of cell
sizes, interference of adjacent cells, andrequired SNR in step S660. In this instance, the
subcarriers which constitutethe resource space 350 or the resource subspace 360 can be
configured by usingat least one subcarrier set which covers a wide frequency band and
has apredetermined spacing.

[76]   In addition, the resource space 350 through whichthe traffic channels are
transmitted can be partitioned into resource subspaces360 by the number of adjacent
cells according to a cell arrangement, a transmitpower higher than another resource
subspace can be allowed to a resourcesubspace 360 for each cell, and the resource
subspace 360 with the allowed hightransmit power can be varied for each adjacent cell.
Also, the user who needs ahigh transmit power for each above-noted cell is required to
use the trafficchannel of the resource subspace 360 having the allowed high transmit
power,thereby reducing the interference of the adjacent cell and increase thefrequency
reuse efficiency.

[77]   Through the above-described method, a cellconfiguration or a cell reconfiguration
for partitioning the resource space350, the resource subspace 360, and the resource sets
370, and assigning thephysical channels and the transmit power in the OFDMA-based
cellular system canbe executed.

[78]   As a result, the preferred embodiment of thepresent invention partitions a resource
(a subcarrier within an OFDM symbol)into resource spaces, averages interference of
the channels having similarcharacteristics in each resource space by using different
frequency hoppingpatterns for the respective cells, and controls the power
transmittable to theresource space for each cell, thereby easily controlling the inter-
cellinterference and increasing the frequency reuse efficiency.

[79]   Also, the inter-cell interference is easilycontrolled for respective channels with
different characteristics in theOFDMA-based cellular system, and a method for par-
titioning the resource spacesand assigning the physical channels for improving the
frequency reuseefficiency is provided, so that the common channels and the control
channelshaving similar required SNRs between two different cells may be collided

eachother, thereby easily controlling the interference from the adjacent cells.

[80]   Further, the resource space for transmitting thetraffic channels between the two different cells is partitioned into subspacesso that the traffic channels within the same subspace may be collided. Strictpower control is performed between the collided channels to control theinterference from the adjacent cells. Then the frequency reuse efficiency ofthe cellular system are increased and thus the performance of the total systemis enhanced.

[81]   While this invention has been described inconnection with what is presently considered to be the most practical andpreferred embodiment, it is to be understood that the invention is not limitedto the disclosed embodiments, but, on the contrary, is intended to covervarious modifications and equivalent arrangements included within the spiritand scope of the appended claims.